STUDIES ON THE ENVIRONMENTAL RADIOLOGICAL IMPACT OF TRITIUM AND CARBON-14 INCLUDING THE ORGANICALLY BOUND FORMS AROUND NUCLEAR FACILITY SITE AT TARAPUR

Synopsis of the Thesis to be Submitted to the Mangalore University for the Award of the Degree of Doctor of Philosophy in Physics

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Studies on the Environmental Radiological Impact of Tritium and Carbon-14, including the Organically Bound forms around Nuclear Facility Site at Tarapur

1.0 Introduction

Nuclear energy is a sustainable resources to cater to the long-time energy need of our country. In line with this, nuclear power stations of various capacities are constructed and operated in different parts of India. Tarapur is the first nuclear power station site in India and it started with two units of (160 MWe) Boiling Water Reactors (BWR) in the year 1969. It is situated on the west coast of India (19^0 50' N, 72^0 41' E), about 100 km north of Mumbai and is a multi-facility nuclear site. In addition to BWR, two units of pressurized Heavy Water Reactors (PHWR) of 540 MWe each (TAPS 3&4) are also operating at this site, with commercial operation starting in 2005-2006. In addition to nuclear power plants, research facilities and back end fuel cycle facilities are also operational at the Tarapur site.

Low-level liquid and gaseous effluents generated during the operation of these facilities are adequately treated and released to the environment with maximum possible dilution under strict regulatory compliance of discharge criteria. Tritium is one of the major constituents of reactor effluents, especially PHWR type reactors. Small quantities of ^{14}C are also generated and released to the environment during the operation of reactors. The radioactive effluents released to the environment undergo dilution and dispersion. However, there is a possibility that radionuclides may enter into environmental food pathways. Hence it is important to study the ecological pathways of the radionuclides released to the environment during the normal operation of nuclear facilities. There are many nuclides found in the liquid, and gaseous effluent discharges to the environment, in which environmental distribution of fission products nuclides like ^{137}Cs, ^{90}Sr, ^{131}I,

etc. and activation products like ^{239}Pu, ^{60}Co, ^{134}Cs, ^{54}Mn, etc. has been well documented by various investigators (Bhat, 1972, Iyer, 1981, Chandramouli,1983, Baburajan, 1998) at Tarapur. There is no published data available on ^{14}C and tritium, especially Tissue Free Water Tritium (TFWT) and Organically Bound Tritium (OBT) at Tarapur. In view of their long half-life and biological involvement, tritium and ^{14}C pose long term environmental radiological impact. The characteristics of tritium, ^{14}C and various environmental sources of these nuclides in addition to the nuclear power plant operations are described below.

1.1 Tritium

Tritium, a low energy beta emitter, $T_{1/2}$= 12.32 y, E_{max}: 18.6 keV and it is present in the environment due to natural and anthropogenic origin has several sources of production in the environment. It is continuously produced in the upper atmosphere as a result of cosmic ray induced spallation and interaction with atmospheric oxygen and nitrogen at an annual rate of 74 PBq (Mccubbin et al., 2001). A large amount of tritium was released to the environment during atmospheric nuclear weapons tests during 1950s and 1960s. It is estimated that 2.96×10^8 TBq of tritium was released to the environment in this way, causing the tritium activity to significantly increase on the earth. The discharges from the nuclear power stations, fuel reprocessing plant and some industries that use ^{3}H result in an enhancement of activity of this nuclide, locally, in different environmental matrices. The tritium releases from Heavy Water Reactors (HWR) are higher than the other types of reactors operating globally. Tritium is produced in heavy water coolant and moderator in HWRs through the ^{2}H (n, γ) ^{3H} reaction, with an estimated production rate of 5.42×10^7 GBq GWe^{-1} y^{-1}(IAEA, 2004). The normalised tritium release from HWRs worldwide is 874 TBq

$(GWa)^{-1}$ through the atmospheric route and 817 TBq $(GWa)^{-1}$ through the liquid route (UNSCEAR, 2010).

1.2 Carbon-14 (^{14}C)

^{14}C is a radioactive isotope of carbon and a pure beta emitter with a half-life of 5730 years; it decays to ^{14}N by emitting low energy beta radiation with an average energy of 49.5 keV maximum energy of 156 keV (IAEA, 2004). In the environment, ^{14}C exists in two forms. As $^{14}CO_2$, it can remain in gas form in the air or becoming bicarbonate and carbonate in water. During photosynthesis, $^{14}CO_2$ is incorporated into the organic material, forming its carbon frame. It is generally present as CO_2 with less than 1% in carbon monoxide, methane formaldehyde, and other molecules. In nature, ^{14}C is mainly produced in the upper atmosphere by cosmic ray (Lal and Peters, 1967) interaction with nitrogen through ^{14}N (n, p) ^{14}C (cross-section σ=1.8b). The ^{14}C produced is quickly incorporated, mainly into molecules of carbon dioxide, mixed throughout the atmosphere and the hydrosphere, the leading long-term reservoir. It has been estimated that the annual production rate of ^{14}C is 1.4×10^{15} Bq, and the total inventory of ^{14}C in the atmosphere was estimated to be 1.4×10^{17} Bq, but much large in the deep ocean of 1.0×10^{19} Bq (IAEA, 2004). The long-term mean specific activity of natural carbon has been determined by measuring tree rings of known age to be 226 Bq/kg C (Karlen et al., 1964). A large amount of ^{14}C has been produced in the atmospheric nuclear weapons tests in 1945-1980, mainly by the reactions of neutrons produced in the nuclear weapons testing with the nitrogen in the atmosphere through ^{14}N (n, p) ^{14}C. Besides, a small fraction of ^{14}C was also produced by a ternary fission reaction of uranium and plutonium during weapons testing. There was a significant increase in the activity of ^{14}C in the atmosphere in the 1950s and 1960s when a large number of atmospheric nuclear weapons testing was

conducted (IAEA, 2004). Nuclear power reactors together with fuel reprocessing plants account for ^{14}C activity releases of 0.44 TBq $(GW \cdot y)^{-1}$ and 0.7 TBq $(GW \cdot y)^{-1}$ respectively (average values for the period 1995-1997) (UNSCEAR, 2000). The total release of ^{14}C from reactors and reprocessing plants until the year 1997 was 2.8×10^{15} Bq (UNSCEAR, 2000).

2.0 Importance of the study

As tritium and ^{14}C are produced naturally and have a contribution from the past weapons test fallout in the environment, it is a difficult task to evaluate the environmental contribution of these nuclides due to the operation of nuclear facilities Tarapur. Under this scenario, methods for measuring the ultra-low level of these radionuclides have to be standardized. The method development/ standardization of the existing method is one of the important scopes of this study. There were no standardized measurement techniques and monitoring practice followed for ^{14}C measurement in air and biological samples at Nuclear Power Plant (NPP) sites in India. A systematic monitoring of ^{14}C in the air and biological samples was planned under this study.

Similarly, measurement techniques have to be standardized for the measurement of Tissue Free Water Tritium (TFWT) and Organically Bound Tritium (OBT) as there was no monitoring practice followed for the measurement of these nuclides in biological and non-biological samples at most of the Indian NPP sites, and especially at Tarapur. As air and edible biological matrices can deliver dose to man through inhalation and ingestion, it is important to quantify the level precisely in the above matrices. This study was undertaken with an objective of generating data on tritium and ^{14}C in the air and other environmental compartments at Tarapur.

3.0 Aims and objectives

The aim and objectives of the studies were:

- To standardize methods for the determination of HTO, TFWT, OBT and ^{14}C in different environmental matrices and ^{14}C in air,
- To establish a database on HTO, TFWT, OBT and ^{14}C in terrestrial, marine and atmospheric environmental matrices and related site-specific environmental transfer parameters in the vicinity of the Tarapur nuclear facility site, and
- To evaluate population dose attributable to the release of tritium and ^{14}C to the environment from the nuclear facilities operating at Tarapur.

4.0 Overview of the work done

A comprehensive literature survey of the work done by various investigators on tritium and ^{14}C monitoring was carried out. The methodology used by various investigators, and their merits and demerits were evaluated. An extensive work was carried out in the standardization of the methodology for the determination of TFWT, OBT and ^{14}C in biological matrices and ^{14}C in ambient air. Various parameters required for the determination of these nuclides were quantified.

A systematic sampling program was planned and executed, covering 30 km around the nuclear site to collect air, fresh water, seawater and rainwater during the rainy season to determine tritium. The geometric mean (GM) activity of air tritium determined was used for the computation of the population dose. Freshwater samples collected from different village wells, bore wells, and reservoirs (Dam) were subjected to tritium determination. It was observed that the tritium in drinking water was found to be <2 Bq L^{-1}, and hence it was not used for computation of population

dose. The seawater samples were collected and analyzed periodically, and it was used for trend analysis for tritium release from the nuclear facilities.

A sampling program was planned and executed to collect air moisture, vegetation and soil simultaneously to study the transfer mechanism of tritium from air→ soil → plant system and air→ plant system. The air temperature and relative humidity were measured during the sampling. The moisture content of the soil was also determined by drying the soil at a constant temperature of 110°C. The HTO or TFWT and OBT concentration were determined for leaf and soil samples collected simultaneously and the soil to air transfer ratio (CR_s), transfer ratio of plant to air (R_{pa}), transfer ratio of plant to soil (Rpw), partition factor, the ratio of OBT to TFWT in plant leaf (R_p-field) and the OBT_{Veg}/OBT_{Soil} ratio were determined under field condition. In addition, the biological samples, like edible vegetable (root vegetable, leafy vegetables, and fruits) and non-edible vegetation, milk, mutton, fish, soil, sediment and seaweed samples were collected and analyzed for TFWT and OBT and OBT/TFWT ratio evaluated.

A study on the cycling of tritium in rice plant grown in the nearby region of nuclear power plant was evaluated for the harvesting seasons of 2016 and 2017. The sampling program was planned for the simultaneous collection of all the matrices involved in the cycling process, like air, soil, paddy grass and paddy seed. The air temperature, relative humidity and soil moisture were recorded, and the paddy processing was carried out as per the standard procedure (HPD, 2010). The TFWT (HTO) and OBT activities in different parts of the rice plants were determined along with tritium in soil and air.

The low-level tritium, released to the marine environment from nuclear facilities, and incorporated by marine matrices TFWT and OBT was studied for three years (2016-2018) at Tarapur.

The site-specific tritium transfer parameters generated under this study were used as input parameters the specific activity model (IAEA, 2010) to ccompared the measured TFWT and OBT with that derived from the tritium transport model for terrestrial and aquatic systems.

One of the objective of this study was to standardize a method for the determination of ^{14}C in the air environment at Tarapur. CO_2 from air was absorbed in NaOH as absorbent for the analysis of activity. It involved a few steps of chemical separation and liberation of CO_2 (including $^{14}CO_2$) and re-absorption in ethanolamine methanol mixture. The uncertainty involved in each step from sampling to measurement was evaluated and incorporated in the computation of ^{14}C activity. A sampling programme was planned to measure ^{14}C in atmospheric air using the standardized method and generated database on ^{14}C activity in the atmospheric environment of Tarapur.

Edible (vegetable, fruits, milk, rice, and fish) and non-edible samples (soil, sediment and seaweed) were collected and analyzed for ^{14}C activity. The impact of the nuclear facilities at Tarapur on the environment was assessed in relation with natural background activity of ^{14}C. The measurement result of HTO in air, TFWT and OBT in food items were used to estimate the dose to the population.

5.0 Outline of the Thesis

The thesis has been divided into nine chapters, and a summary of the work presented in each chapter is given below.

Chapter 1. Introduction and review of the literature

This chapter provides details about the occurrence and sources of Tritium (HTO), TFWT, OBT, and ^{14}C, in the environment. The global inventory of these nuclides and their annual

production are discussed in detail. The studies reported by previous investigators in India and elsewhere in the world on this subject, and the environmental levels of these nuclides at the various NPP sites are also discussed in the chapter. The extensive literature survey includes literature published in national and international journals, reports, thesis published, etc. The literature survey indicated that a systematic study on tritium activity in various forms and ^{14}C in the Tarapur environment is not available. There is a need to establish database on these in different environmental matrices to understand their transport in the environment and for radiological impact assessment. The relevance of the study along with the aim and objective are outlined in this chapter.

Chapter 2. Experimental techniques and Standardization of methods

This chapter presents the methodology used for collecting and processing the atmospheric, terrestrial and marine samples and determination of activity concentration of ^{3}H and ^{14}C. This chapter also describes different instrumental techniques used for the processing of the samples, counting techniques used, calibration of instruments used, minimum detectable activity (MDA) of HTO, OBT and ^{14}C for different biological samples. Various parameters used for the accurate determination of the above nuclides were also discussed in this chapter. Details of sample combustion system to separate ^{3}H and ^{14}C from the sample are presented. The parameters optimized for the combustion and LSC such as optimization of sample volume, channel window selection of LSA for best figure of merit (FOM), percentage recovery and memory effect of ^{3}H and ^{14}C in oxidizer and minimum detectable activity (MDA) of these nuclides for different sample matrices are discussed in details.

Chapter 3. Tritium in air and water around Tarapur

The air and water are the primary recipient medium of the atmospheric and aquatic release of tritium into the environment. This chapter describes the results of studies on tritium distribution in various environmental compartments, namely air, rainwater, fresh water, and seawater. The annual average air tritium activity at different zonal distances around the power plant was used for the computation of population dose. It was observed that beyond 10 km distance from NPP the air tritium activity was below the detection limit of 0.05 Bq m^{-3}. Important observation on seawater tritium are presented and the transport along the coast is discussed in the chapter. The tritium activity in drinking water was below the detection level of <2 Bq L^{-1}. The rainwater tritium activity and corresponding air tritium activity were used to generate scavenging ratio, tritium surface loading, and wet deposition velocity for the Tarapur site. The mean surface loading and wet deposition velocity derived were $1.14x10^{-2}$ Bq m^{-2} s^{-1} and $4.82x10^{-2}$ m $s^{-1,}$ respectively. The wet deposition velocity was comparable with the values reported by James et al., 2010 ($7.4x10^{-2}$ m s^{-1}) and Gaikwad et al., 2014 ($1.69x10^{-2}$ ms^{-1}) for Kaiga and Tarapur sites, respectively.

Chapter 4. Tritium transport through terrestrial and aquatic species Tarapur

This focus of this chapter is on the two main objectives of (i) estimating site-specific database on HTO in air moisture, soil water, and TFWT and OBT in different environmental matrices, which are input parameters for tritium transport model and (ii) estimating the annual mean activity of TFWT and OBT in dietary components for the computation of ingestion dose to the member of the public.

The site-specific parameters generated were soil to air transfer ratio (CR_s), transfer ratio of plant to air (R_{pa}), transfer ratio of plant to soil (R_{pw}) and partition factor, the ratio of OBT to TFWT in plant leaf ($R_{p\text{-field}}$) under field condition. The ratio of OBT/HTO in soil, sediment and OBT/TFW in seaweed and marine organisms was also derived and discussed in this chapter. The GM value of CR_s was found to be 0.50 with a GSD of 3.52, and the observed mean value was found in good agreement with the IAEA reported value (IAEA, 2009).

A case study on the activity of TFWT and OBT in rice plants exposed to tritium releases from the NPP, grown around NPP site at Tarapur, during the harvesting seasons of 2016 and 2017 is presented and discussed (Baburajan et al., 2019). The GM value of TFWT and OBT concentrations in rice samples were 8.58 Bq L^{-1} (GSD: 4.22) and 18.8 Bq L^{-1} (GSD: 1.51), respectively, in the 1.6 -5.0 km zone. Another case study on the aquatic system focused on transfer of HTO from seawater to sediment, marine algae and marine organisms and formation of OBT in the marine ecosystem at Tarapur over a period of three years (2016 to 2018) (Baburajan et al.,2020) is also discussed.

Under the OBT to TFWT ratio R_p-field (R_{pf}) was determined for field condition for different types of plants, categorized into shrubs and tree plant, and the ratio of OBT to TFWT in leaves (R_{pf}) samples were determined separately. The R_{pf} value for plant leaf computed for shrubs and trees ranged from 0.32 to 19.4 and 0.57 to 15.0 with a GM value of 4.63 and 3.66, respectively. The observed values were similar to report the ratios reported by Thompson et al., 2015, in the vicinity of four nuclear sites in Canada. The edible vegetables (leafy, root and fruit vegetables**)** samples analyzed during 2014-2018 for TFWT and OBT showed the highest annual GM concentration of 6.8 Bq L^{-1} (GSD: 2.27) and 64.7 Bq L^{-1} (GSD: 2.1) respectively in 1.6-5 km zone.

The study also focused on measuring TFWT, and OBT concentrations in other dietary items viz, meat, milk and marine fish for ingestion dose evaluation. The result of the measurements are discussed in this chapter.

Chapter 5. Comparison of the measured TFWT and OBT with that derived from the tritium transport model

One of the objective of the present work was to use the generic tritium transport model for the computation of TFWT and OBT in the terrestrial plant (leaf) and aquatic organism. The site-specific transfer ratios of tritium, derived in this study, were used as input parameters for tritium transport model and the details are discussed in this chapter. The results of relevant transfer ratios for the tritium transport model-derived at the Tarapur site are input to the atmospheric and aquatic tritium transport model, and the details are discussed in this chapter. The TFWT and OBT in terrestrial plant and aquatic organisms were computed using release rate of the NPP, dilution factors for the respective sampling stations.

The study on validation of the aquatic model indicated that the computed activity under predicts the measured activity of HTO and OBT in marine animals at Tarapur. This may be because highly dynamic sea, and a steady-state and equilibrium condition among the parameters studied is rarely attained.

In the case of atmospheric release, the model provides an under estimation of TFWT and OBT in plant leaves when compared to the measured values. The possible reasons for the under prediction of are discussed in the chapter. It was concluded that generic model is not sufficient to predict TFWT and OBT in highly dynamic environmental conditions. A need to

develop a suitable model that can take account of all the environmental conditions was identified through this study.

Chapter 6. Standardisation of a method for the determination of atmospheric ^{14}C and its activity in the vicinity of Tarapur Nuclear Site

This chapter presents the details on the standardization of the method for determining ^{14}C in ambient air, including the optimization of volume of the absorbent, recovery at a different stage of bubblers, and chemical recovery of the analytical process. A method based on the absorption of CO_2 in NaOH solution in a bubbling setup was standardized to measure ^{14}C in ambient air (Baburajan et al., 2020b). The mean absorption percentage for a single-stage bubbler was 62.2 ± 4.6%, and the chemical yield of the whole analytical process of precipitation and re-absorption was determined by ^{14}C standard spike experiments and found to be 84.2 ± 7.2%. An MDA value (at 3σ) of 0.05 Bq m^{-3} (specific activity of 0.25 Bq g^{-1} C) was achieved, which considers all the uncertainty associated with the analytical method. The uncertainty associated with the method was evaluated and propagated relative uncertainty was 11.9 %. Result of extensive measurements of ^{14}C in the vicinity of Tarapur NPP are presented and the suitability of the method for detecting ^{14}C in ambient air is discussed. The ^{14}C activity observed at Tarapur were lower than reported for PHWR and Fuel Reprocessing environment elsewhere in the world (Kim et al., 2000, Foutugne et al., 2004). The results confirm no significant increase in ^{14}C activity in the air at Tarapur.

Chapter 7. Carbon-14 in terrestrial and aquatic species at Tarapur

This chapter provides the results of the determination of ^{14}C activity in terrestrial and aquatic environmental samples at Tarapur. The stable carbon content determined for the environmental sample varied from 9.93% to 44.3%, with the lowest for soil sample and highest for paddy rice samples. ^{14}C activity was measured in different samples of viz edible samples; vegetation (leaf, fruit and stem), milk, meat, rice and fish; non-edible samples, soil, sediment and seaweed. The data on ^{14}C activity generated on these samples are found within the natural background level. For example, the rice sample analyzed yielded a ^{14}C activity of 235.2 ± 9.93 Bq kg^{-1} C, which is similar to the natural background of 230 Bq kg^{-1} C.

Chapter 8. Environmental impact assessment due to the release of tritium and carbon-14 at Tarapur

The impact due to the activity of HTO, TFWT, OBT and ^{14}C in air and different food items from various locations/ zonal distance around the NPP site at Tarapur is discussed in this chapter. The dose computation method and the parameters used for the computation of population dose are also discussed in the chapter. The overall mean activity of tritium in the air during the study period of 2014-2018 was 0.064 Bq m^{-3} in 1.6- 5 km zone, and the corresponding population dose is computed to be 0.017 µSv y^{-1} (due to inhalation and skin absorption). The population dose due to TFWT and OBT in dietary products based on local dietary data (Patil et al., 2004) was 0.0134 µSv y^{-1} and 0.0514 µSv y^{-1} respectively with a total dose of 0.082 µSv y^{-1} for general public.

In order to identify the representative member of the public, population of the region is classified in to three groups *viz*. farmer, fisherman and others (population not falling in the above

to two groups) and dose was calculated based on the dietary habits of the respective group. It was found that the total dose to the individual group were 0.091 μSv y^{-1} to the farmers, 0.083 μSv y^{-1} to the fisherman and 0.071 μSv y^{-1} to other group. The maximum dose to the representative man due to tritium releases from the nuclear facilities at Tarapur was computed to be 0.091 μSv y^{-1} out of which 66.5% is contributed by OBT and 14.7% contributed by TFWT. The computed population dose due to the consumption of food items and inhalation of tritium was found to be negligible when compared to the population dose limit of 1000 μSv y^{-1} to public (ICRP 103, 2007).

For the first time, population dose due to the TFWT and OBT was evaluated for the Tarapur site. Among different food items, a significant contributor to the OBT dose was rice intake by the local public. The amount of excess ^{14}C above the natural background level was found to be negligible, and hence the population dose due to ^{14}C was not evaluated for ingestion dose. The inhalation dose due to ^{14}C was found to be insignificantly low.

Chapter 9: Summary and Conclusions

In this chapter, the important findings of the research work and application of the study in the environmental monitoring program at Tarapur in particular and other NPPs of India are discussed. The suggestions for future studies in this area is also presented at the end of this chapter.

5.0 Research Publications in Journals, National and International Conferences related to the thesis work

Journal publications:

LIST OF PUBLICATIONS OF THE AUTHOR

Research Publications in Journals, National and International Conferences related to the thesis work

1. **Baburajan A**., Gaikwad R.H., Sudheendran V., Shah C.A., Ravi P.M., Karunakara N., 2019. Organically bound and tissue free tritium in rice plant grown around Tarapur Atomic Power Station, West Coast India.' Journal of Radioanalytical and Nuclear chemistry (JRNC), Vol. 297, No.3. DOI.10.1007/S10967-019-06441-9.

2. **Baburajan A**., Sudheendran V., Gaikwad R.H., Ravi P.M., Rashmi Nayak S, Renita Shiny D'Souza, Karunakara N., 2019. Tissue Free Water Tritium (TFWT) and Organically Bound Tritium (OBT) in Marine ecosystem at Tarapur on the West Coast of India; Published online. Journal of Radio analytical and nuclear chemistry (JRNC), Vol.323, No.3. DOI 10.1007/s10967-019-06441-9.

3. **Baburajan A**., Sushant S. Dalvi, Sudheendran V., Varakhedkar V. K., Saradhi I.V., Ravi P.M., Karunakara N., 2020. Validation of a method for measurement of Carbon-14 in air and its application for estimation of ^{14}C levels around Tarapur nuclear site; Published online. Journal of Radioanalytical and nuclear chemistry (JRNC), Vol. 324, Issue No.2. DOI 10.1007/s10967-020-07118-4.

4. **Baburajan A**., Sudheendran V., Gaikwad R.H., Ravi P.M., Karunakara N., 2019. HTO and Organically Bound Tritium (OBT) in Marine Ecosystems at Tarapur. Proceeding of

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5. **Baburajan A**., Rajaram S., Renita Shiny D'Souza, Rasmi Nayak, Karunakara N., Ravi P.M., Tripathi R.M., 2018. Experience of an Inter-laboratory Exercise for the Determination of Carbon-14 in Biological Samples. International Conference on Developments towards improvement of Radiological Surveillance at Nuclear Facilities and Environment, IARPIC-2018, 33rd IARP conference January 16-20, Mumbai, Page no.141.

6. **Baburajan A**., Sushant S. Dalvi, Sudheendran V., Ravi P.M., Karunakara N., 2017. Standardization of an analytical method for Carbon-14 in air and its associated uncertainties. NUCAR-2017, KIIT, Bhubaneswar, 6-10 Feb.2017.

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1. Srinivas S. Kamath, Narayana B., Renita Shiny D'Souza, Rashmi Nayak S., Mohan M. P., Dileep B. N., **Baburajan A**., Ravi P. M., Karunakara N. 2018. Tritium concentration in ambient air around Kaiga Nuclear Power Plant. Radiat. Protect. Environ. 41: 16-19.

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